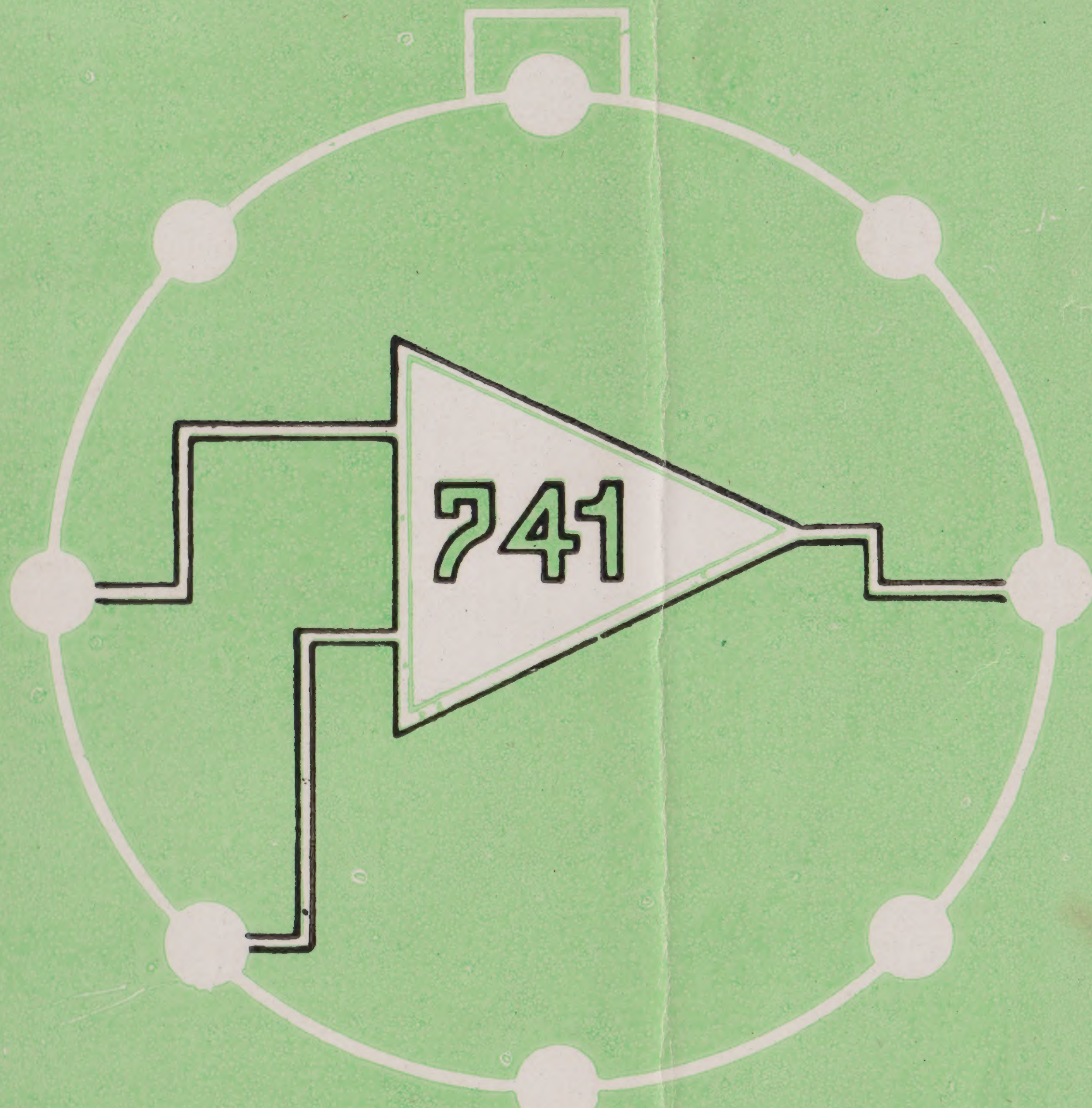
41 PROJECTS USING 741 I.C.



M.C. Sharma

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41 Projects using 741 OP Amp

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PREFACE

The Operational Amplifier IC741 is perhaps one of the most inexpensive IC available in the market. Yet it is comparable to the best of such IC's in respect of versatility and superb performance. It is, therefore, natural that there is hardly any electronic magazine in the world which does not contain a project using this IC.

This book which is now in your hands contains 41 projects employing this IC. You will find the electrical details of this IC in the book itself, which make them so versatile.

These projects will provide the hobbyist, the experimenter and even the professional, practical experience in making these projects. In this connection, we would like to emphasise two aspects: firstly, good soldering and the use of IC Sockets. It is not proposed to go into the details of good soldering, but, please bear in mind badly-soldered joints will invariably disappoint you in the performance of the project, no matter how well the circuit is designed or how good are the individual components.

Secondly, it is always a good practice to use an IC socket, wire it up and then insert the IC in the socket in the CORRECT way.

At this stage, it will be appropriate to indicate that this IC741 is not capable of driving a loudspeaker directly. Its output is usually connected to an output amplifier stage. At times, however, this IC may be designed to actuate a pair of earphones.

The author Mr. M.C. Sharma is not new to our readers. Suggestions for improvement will be gratefully received by him as well as ourselves.

Publishers

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INTRODUCTION

An operational amplifier, often referred to as an Op Amp, is a very high gain high performance amplifier designed to amplify ac and dc signal voltages. Modern integrated circuit technology and large scale production techniques have brought down the prices of such amplifiers within reach of all amateurs, experimenters and hobbyists. The Op Amp is now used as a basic gain element, like an elegant transistor, in electronic circuits.

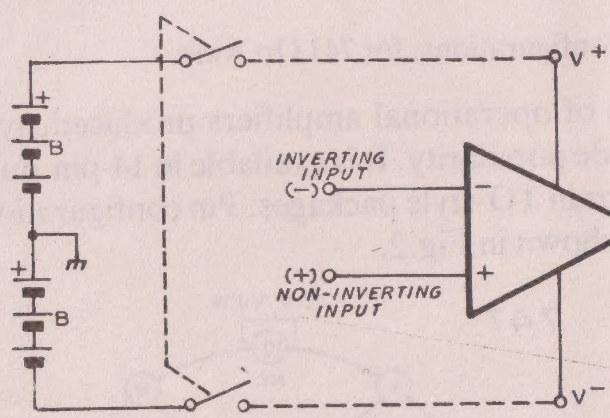

Fig. 1. Symbol for an Operational Amplifier.

A symbol used to represent an operational amplifier in schematics is shown in Fig. 1. The operational amplifier has two inputs and only one output. One input is called the **inverting** input and is denoted by a minus sign. A signal applied to this input appears as an amplified but phase inverted signal at the output. The second input is called a **non-inverting** input and is denoted by a plus sign. A signal applied to this input appears at the output as an amplified signal which has the same phase as that of the input signal.

The availability of two input terminals simplifies feedback circuitry and makes the operational amplifier a highly versatile device. If a feedback is applied from the output to the inverting input terminal, the result is a negative feedback which gives a stable amplifier with precisely controlled gain characteristics. On the other hand, if the feedback is applied to the non-inverting input, the result is positive feedback which gives oscillators and multivibrators. Special effects are obtained by combination of both types of feedbacks.

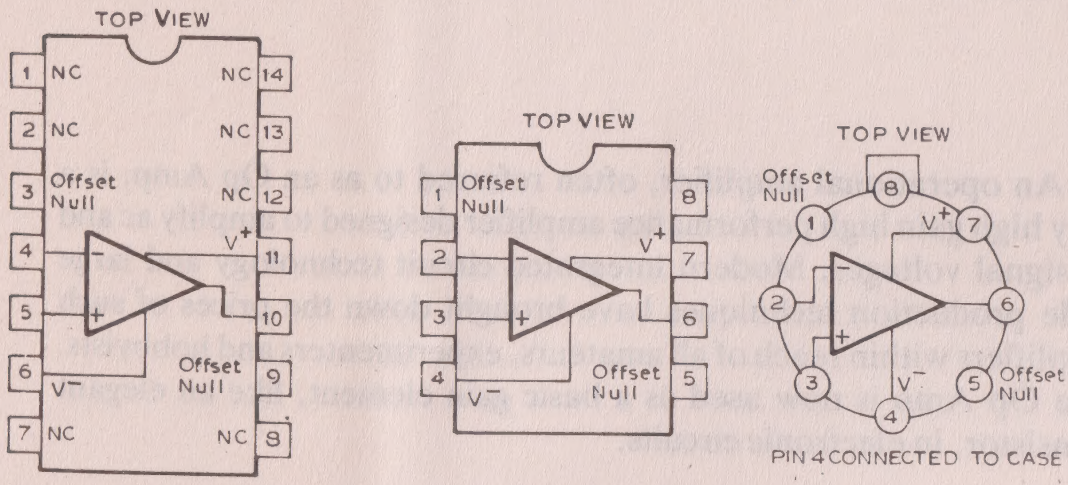

Fig. 2. Pin Configurations, for 741 Op Amp.

Of the different types of operational amplifiers produced, type 741 has achieved a very wide popularity. It is available in 14-pin dual-in-line, 8-pin dual-in-line or in TO-style packages. Pin configurations for all these packages are shown in Fig.2.

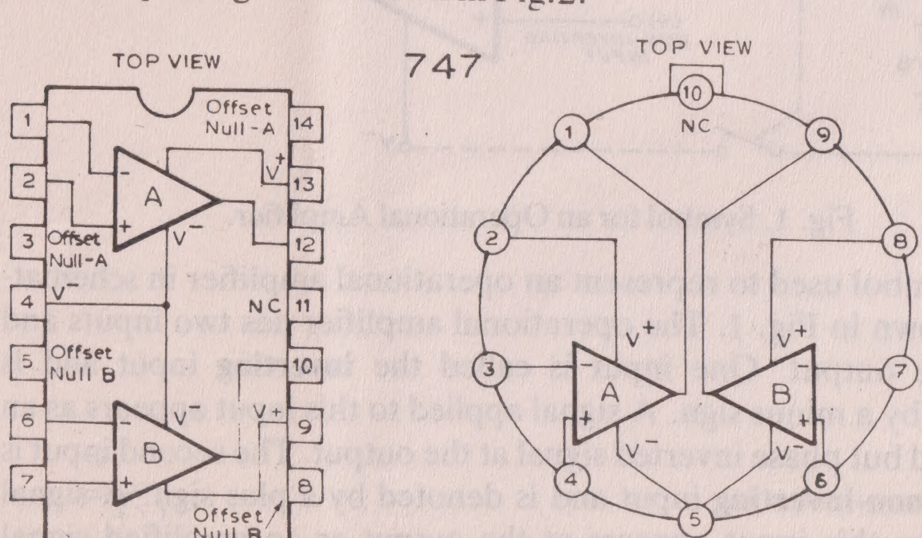

Fig. 3. Pin Configurations, for Type 747 Dual Op Amp.

Integrated circuit type 747 accommodates two type 741 operational amplifiers in a single package. Pin configurations for different packages are shown in Fig.3.

The operational amplifier needs a dual symmetrical power supply with its centre tap grounded as shown in Fig. 1. This enables the operational amplifier to amplify dc signals of both polarity, positive or negative, with respect to ground. The circuit is so designed that if both inputs are connected to ground, the dc output voltage is zero. However, because of small internal unbalances, a small dc voltage may appear at the output. It is too small to be objectionable in normal applications. For critical applications, the output voltage can be set precisely to zero by connecting a 10k potentiometer between terminals marked "offset-null" as shown in figures 4 and 5.

It is possible to operate the 741 on a single rail supply also. This is usually done by raising the standing dc input voltage to the non-inverting input terminal to approximately half the supply voltage by a voltage divider network, as done in figures 11, 12 etc. The output dc voltage in such cases stands at half the supply voltage. But this does not matter because the dc can be easily blocked by a capacitor allowing only the ac signal to be passed on to the next stage.

Operational amplifier type 741 has many features that have made it so popular. It has a built-in circuitry that provides full protection against output overloads or even shorts to ground for any length of time. The 741 does not need any external component for phase compensation or adjusting its frequency response. This simplifies circuit design and minimises the number of components used. Its frequency response has a smooth roll-off at the high end which keeps the circuit fully stable in all feedback configurations. Important technical parameters of type 741 are given below:

Parameter	Min.	Typ.	Max.	Units
Supply Voltage	± 5		± 18	V
Supply Current		1.7	2.8	mA
Input Bias Current		80	500	nA
Input Resistance	0.3	2.0		M Ω
Input Offset Voltage		2.0	6.0	mV
Offset Voltage Adjustment Range		± 15		mV

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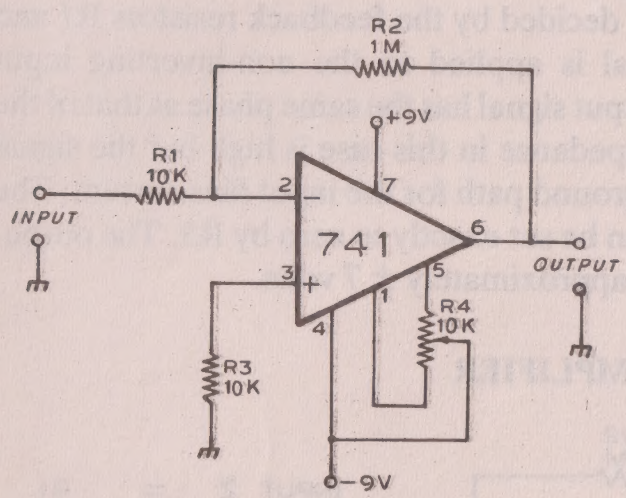
PRACTICAL PROJECTS

1. INVERTING DC AMPLIFIER



INPUT Z $= R1$

$= 10\text{ K}$

GAIN $= -\dfrac{R2}{R1}$

$= 100$

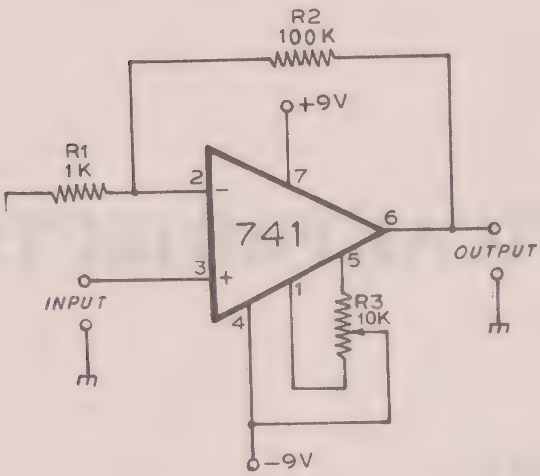
BANDWIDTH $= \dfrac{1\text{MHz}}{\text{GAIN}}$

$= 10\text{ KHz}$

Fig. 4. General Purpose Inverting DC Amplifier.

A general purpose inverting type of dc amplifier operating on a dual symmetrical supply of ± 9V is shown in Fig. 4. The input signal is applied to the inverting input terminal of the 741 and the output signal is therefore, phase inverted. The amplifier gain is decided by the ratio of the feedback resistors R1 and R2. The standing dc output voltage can be set exactly to zero by R4. The maximum output voltage swing is about ± 7 volts.

2. NON-INVERTING DC AMPLIFIER.



INPUT Z > 1M

GAIN $= 1 + \frac{R2}{R1}$

$= 101$

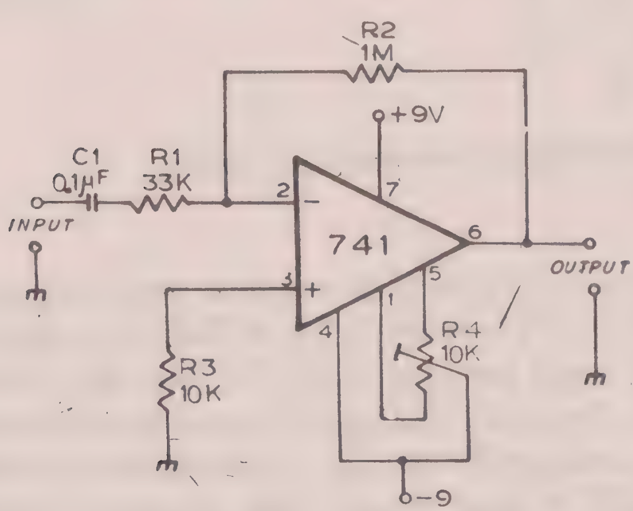
BANDWIDTH $= \frac{1\text{MHz}}{\text{GAIN}}$

$= 10$ KHz

Fig. 5. General Purpose Non-inverting DC Amplifier.

A general purpose non-inverting type of dc amplifier operating on a dual symmetrical supply of ±9V is shown in Fig. 5. As befor. the gain of the amplifier is decided by the feedback resistors R1 and R2. Since the input signal is applied to the non-inverting input terminal of the 741, the output signal has the same phase as that of the input signal. The input impedance in this case is high but the signal source must provide a dc ground path for the input bias current. The standing output voltage can be set exactly to zero by R3. The outpu. voltage swing is limited to approximately ± 7 volts.

3. INVERTING AC AMPLIFIER



INPUT Z = R1

= 33K

GAIN $= \frac{R2}{R1}$

$= 30$

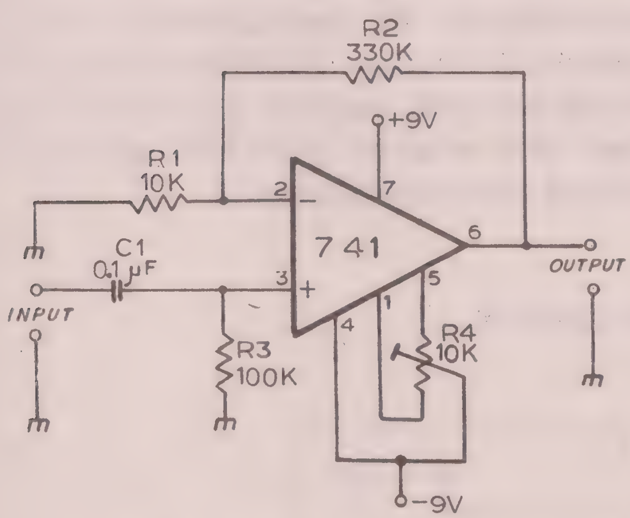
BANDWIDTH = 50Hz to 30 KHz

Fig. 6. General Purpose Inverting AC Amplifier.

Fig. 6 shows a general purpose inverting type of ac amplifier. As the input signal is applied to the inverting input terminal, the output signal is phase inverted. The amplifier gain is decided by the ratio of the feedback components R1 and R2. The low-frequency roll-off is decided by C1. The amplifier gain falls by 3 dB at a frequency where the reactance of C1 becomes equal to R1.

For direct coupling to the next stage, the standing dc can be set exactly to zero by R4. For ac coupling via a capacitor, R4 can be omitted.

4. NON-INVERTING AC AMPLIFIER



INPUT Z = 100K

GAIN $= 1 + \frac{R2}{R1}$

$= 34$

BANDWIDTH = 15Hz to 30KHz

Fig. 7. General Purpose Non-inverting AC Amplifier.

A general purpose non-inverting type of ac amplifier is shown in Fig. 7. The input signal is applied to the plus input of 741 and the output therefore, has the same phase as that of the input signal. Amplifier gain can be set to any value by choosing R1 and R2 but, the higher the gain, the lower will be bandwidth of the amplifier. R3 provides a dc ground path to the bias current. The gain falls by 3 dB at a frequency where reactance of C1 equals R3. R4 may be omitted if the amplifier output is to be coupled to the next stage through a capacitor.

5. DC VOLTAGE FOLLOWER

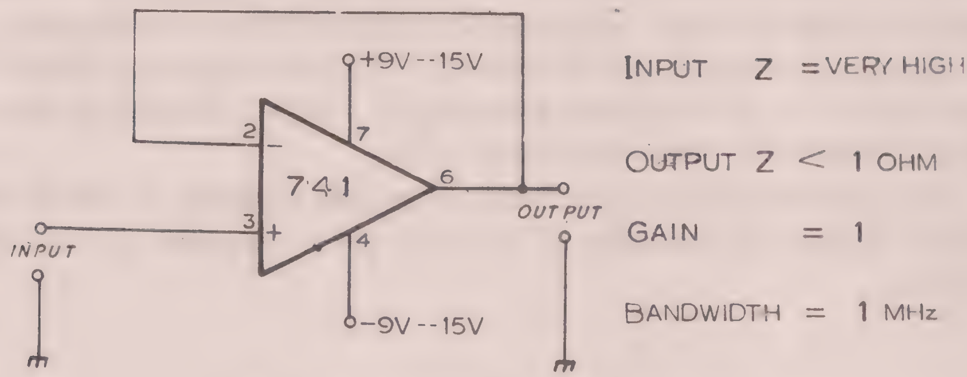


Fig. 8. Unity Gain DC Voltage Follower.

A direct coupled unity gain voltage follower is shown in Fig. 8. The circuit is useful for impedance transformation. Because of hundred per cent negative feedback., the input impedance is very high, and the output impedance is very low. The frequency response extends up to 1 MHz. The signal input source must provide a direct path to ground of less than 100k ohms for input bias current. The circuit can deliver load current up to 10 milliamperes.

6. AC VOLTAGE FOLLOWER

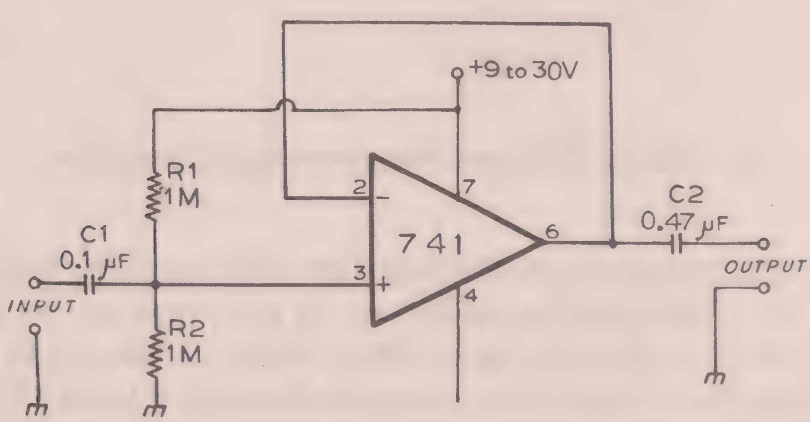


Fig. 9. AC Coupled Voltage Follower.

An ac coupled unity gain voltage follower operating on a single supply is shown in Fig. 9. Voltage divider network of R1 and R2

provides a dc voltage equal to half the supply voltage to the non-inverting input of the 741. The output dc voltage therefore stands at half the supply voltage. The output signal swings above and below this value. The standing dc voltage at pin 6 does not matter because the output is coupled to the next stage via a capacitor.

The input impedance is equal to the value of R1 and R2 in parallel, i.e. 500k ohms in this case. Because of hundred per cent negative feedback, the output impedance is very low. For low frequency applications C1 and C2 can be replaced by electrolytic capacitors of large values.

7. XTAL PICKUP PREAMPLIFIER

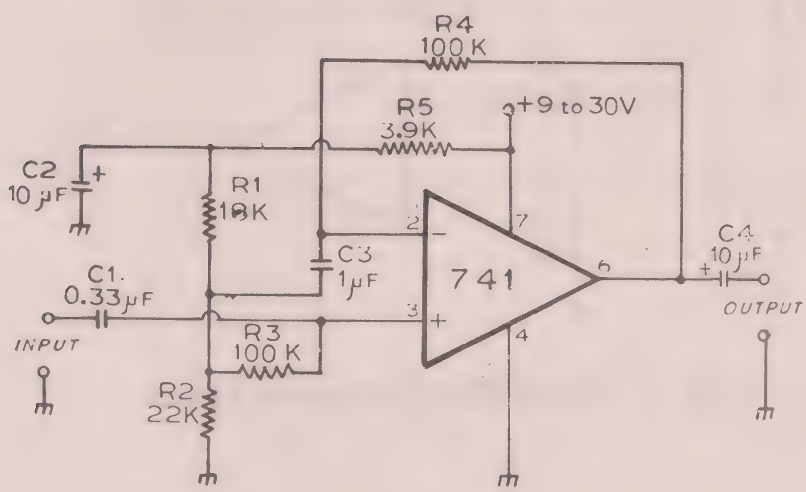


Fig. 10. Preamplifier for a Crystal Pickup.

A preamplifier operating on a single supply and suitable for use with high impedance type crystal pickups is shown in Fig. 10. The circuit is basically a non-inverting ac amplifier (see Fig. 7) in which the gain is dependent on the feed back resistor R4. The smaller is the R4, the lower will be the gain. The low-frequency roll-off characteristics are decided by C3.

Voltage divider network comprising of R1, R2 and R5 provide a dc bias of about half the supply voltage to the non-inverting input of 741. The dc output at pin 6 therefore stands at half the supply voltage.

R5 and C2 form a supply line filter to reduce the hum level as well as to reduce the chances of motorboating when the preamplifier is operated on a common power supply.

8. MAGNETIC PICKUP PREAMPLIFIER

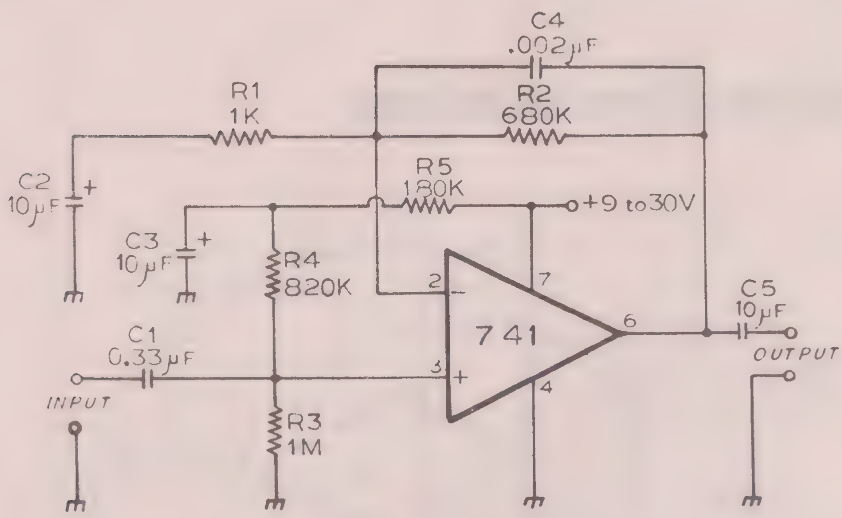


Fig. 11. Preamplifier for Magnetic Pickup.

A preamplifier for magnetic pickups of record players is shown in Fig. 11. The 741 is used as an ac coupled non-inverting amplifier operating on a single supply. The amplifier gain is decided by the feedback components in which C2 controls the low frequency roll-off characteristics while C4 reduces the gain at high frequency end to compensate for the pickup characteristics. R3, R4 and R5 form a voltage divider to give a bias of about half the supply voltage to the non-inverting input of 741. The output at pin 6 therefore stands at half the supply voltage. R5 and C3 form a supply line filter to reduce the hum level and also to eliminate motorboating in case the preamplifier is operated on a common supply with other circuits.

9. MAGNETIC MIKE PREAMPLIFIER

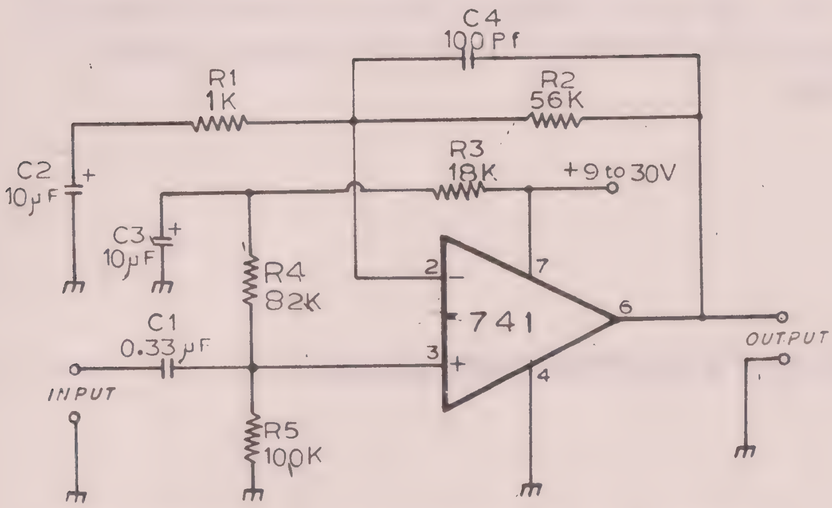


Fig. 12. Preamplifier for Magnetic Micropnone.

Fig. 12 shows a preamplifier operating on a single supply and suitable for magnetic microphones. The circuit operation is very similar to that of Fig. 11. The output can be ac coupled to the next stage via a capacitor.

10. GUITAR PREAMPLIFIER

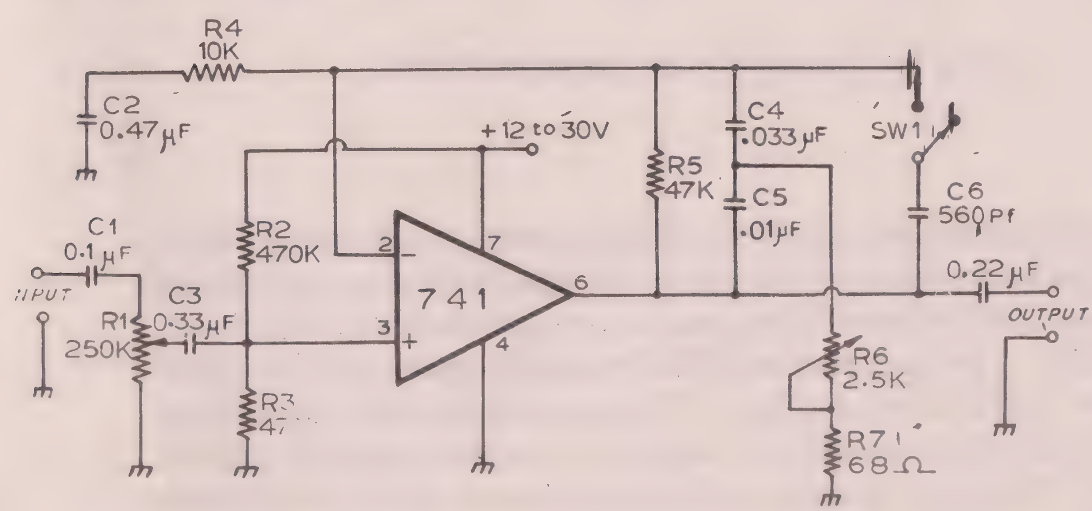


Fig. 13. Preamplifier for Electric Guitar.

A preamplifier suitable for use with high impedance type electric guitar pickups is shown in Fig. 13. The circuit is basically similar in operation to those shown in figures 10 and 11. Potentiometer R6 forms the tone control. Switch Sw1 is used to produce 'brilliant' or 'soft' tonal effects.

11. TELEPHONE PICKUP PREAMPLIFIER

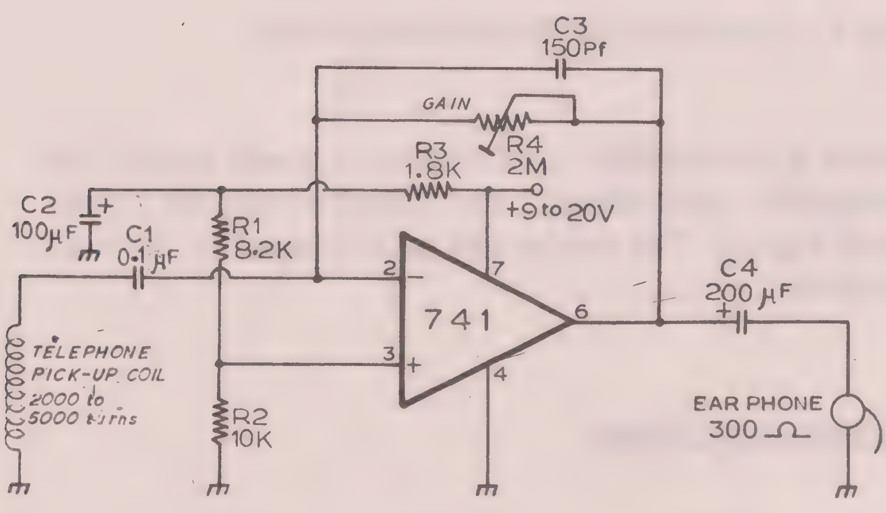


Fig. 14. Preamplifier for Telephone Pickup.

If a high impedance coil with open magnetic core is placed near a telephone instrument or near one of the telephone wires, it picks up inductively both sides of telephonic conversation without any electrical contact. A preamplifier suitable for amplifying tiny signals picked up by the coil is shown in Fig. 14. The circuit is basically an inverting amplifier similar in operation to figure 6. Variable resistor R4 sets the gain and the circuit delivers sufficient output to drive an earphone directly.

12. MIXER AMPLIFIER

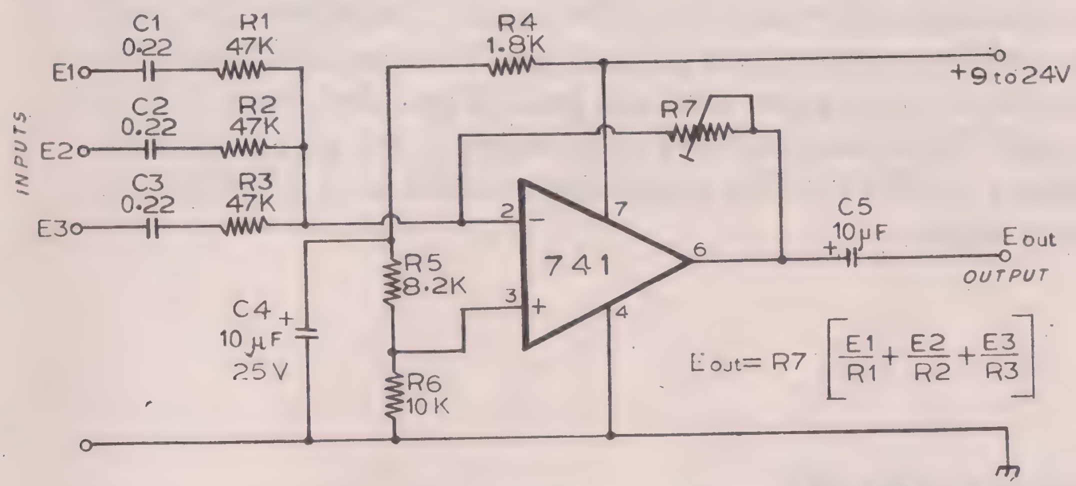


Fig. 15. A Mixer Amplifier.

An operational amplifier works as a highly efficient device for mixing a number of input signals without any interaction. In Fig. 15 the 741 is used as an inverting amplifier and the input signals are applied to the inverting input through individual weightage resistors R1, R2 and R3. These can be variable resistors to adjust the proportion of each input signal in the final output. The overall circuit gain is set by R7. Divider network R4, R5 and R6 provide a dc bias to the non-inverting input equal to half the supply voltage to enable operation on a single supply. Bypass capacitor C4 reduces supply line noise and hum.

13. TONE CONTROL

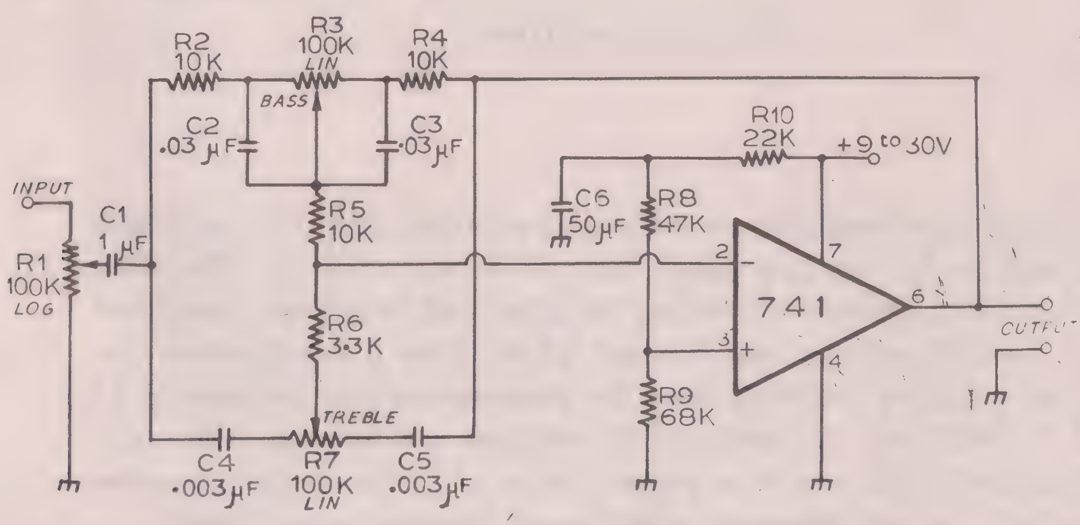


Fig. 16. Independent Bass and Treble Controls.

A preamplifier circuit providing independent Bass and Treble tone controls is shown in Fig. 16. The circuit is basically an inverting type amplifier operating on a single supply. The tone control network is inserted in the negative feedback path. It provides about 15dB of Bass and Treble cut and boost with respect to the gain at the mid-frequency of 1000 Hz. The output can be either ac or dc coupled to the next stage.

14. SIGNAL TRACER

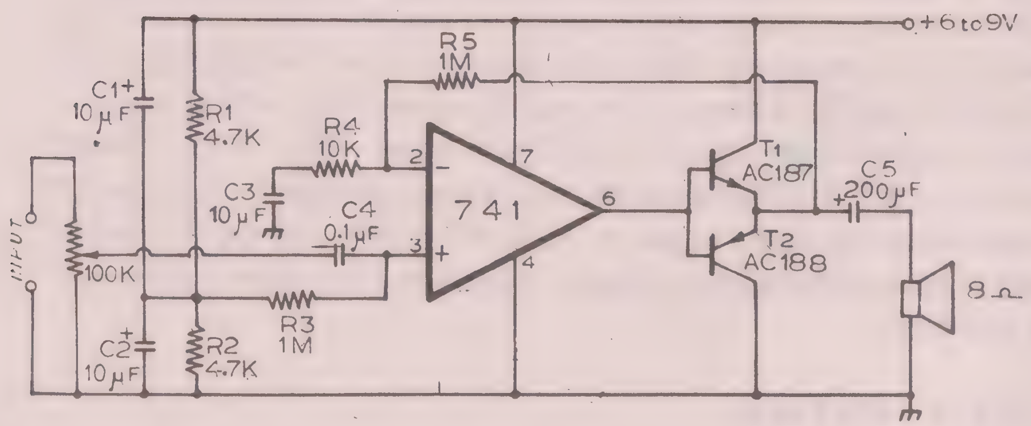


Fig. 17. Signal Tracer.

A high gain amplifier operating on a battery pack of 6 or 9 volts and suitable for use as a signal tracer is shown in Fig. 17. The 741 is used as a high gain non-inverting amplifier and its output is amplified by a complementary pair T1 and T2 to drive a loudspeaker. An overall negative feedback from the common emitter junction of T1 and T2 stabilises the amplifier dc voltages and its gain. The audio output is enough to serve as a signal tracer. A diode input probe at the input will convert this audio signal tracer into an rf signal tracer.

15. 3W AMPLIFIER

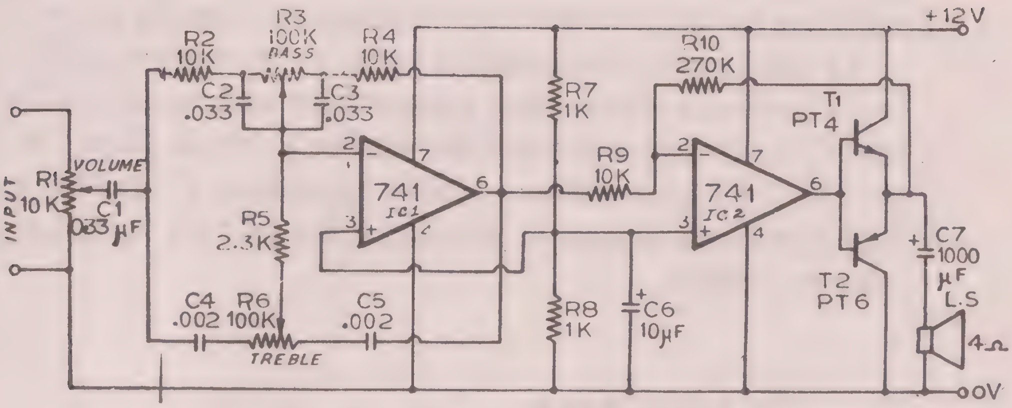


Fig. 18. 3 Watt Audio Amplifier.

A general purpose 3 watt audio amplifier operating on a single supply of 12 volts is shown in Fig. 18. The first 741 is used as a tone control circuit (see Fig. 16) and is directly coupled to the next 741. DC bias for the non-inverting input terminals of both operational amplifiers is provided by R7 and R8. The output of second 741 is amplified by complementary transistor pair T1 and T2. The frequency response extends to 30 kHz and the circuit needs an input signal of about 0.5 volts for full power output.

16. INTERCOM

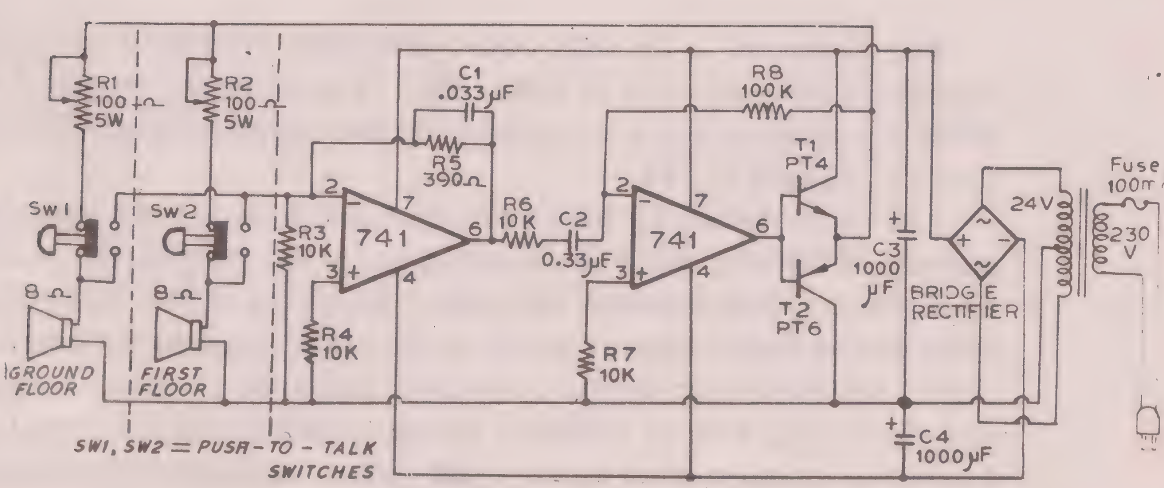


Fig. 19. Two position Intercom.

An intercom circuit operating on a dual symmetrical mains operated power supply is shown in Fig. 19. The figure shows only two positions but any number can be added in a similar manner.

In this circuit, the speakers serve as microphones also. The first 741 is used as a microphone preamplifier and the second 741 with T1 and T2 form a power amplifier similar to those shown in figures 17 and 18. A bridge rectifier and filter capacitors C3 and C4 provide the dual symmetrical supply. Resistors R1 and R2 serve as individual volume controls.

17. 12 W AMPLIFIER

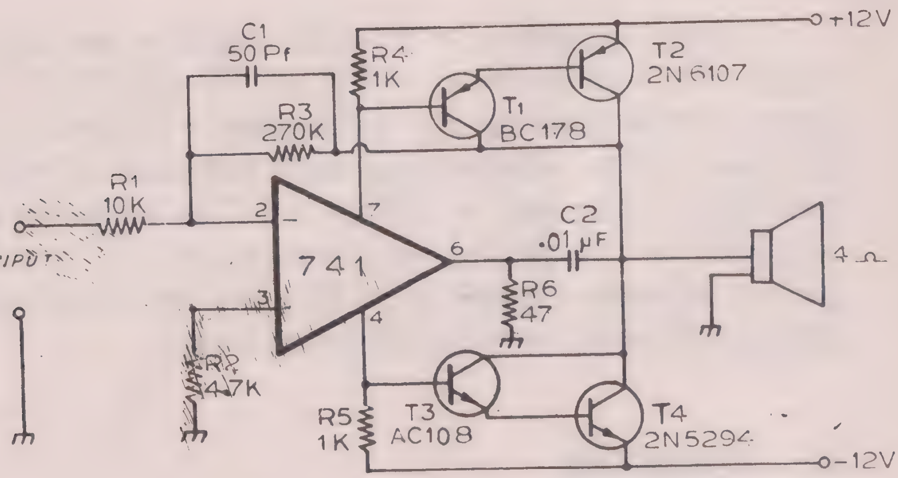


Fig. 20. A 12 Watt Amplifier.

Fig. 20 shows a 12 watt audio amplifier operating on a dual symmetrical supply of ± 12 volts. The 741 provides the required gain while the speaker drive is provided by the complementary Darlingtons T1, T2 and T3, T4.

The input signals for the Darlingtons are derived from the supply current of the 741. Since R6 is connected to the ground, the positive or negative signal currents also pass through R4 or R5. The voltage drop across these resistors serves as the input signal to the transistor pairs. An overall dc negative feedback from the common collector junction of T2 and T4 stabilises the dc conditions of the circuit and keeps the junction point at zero volts. Hence, no coupling capacitor is required for the speaker.

18. DC MOTOR CONTROL

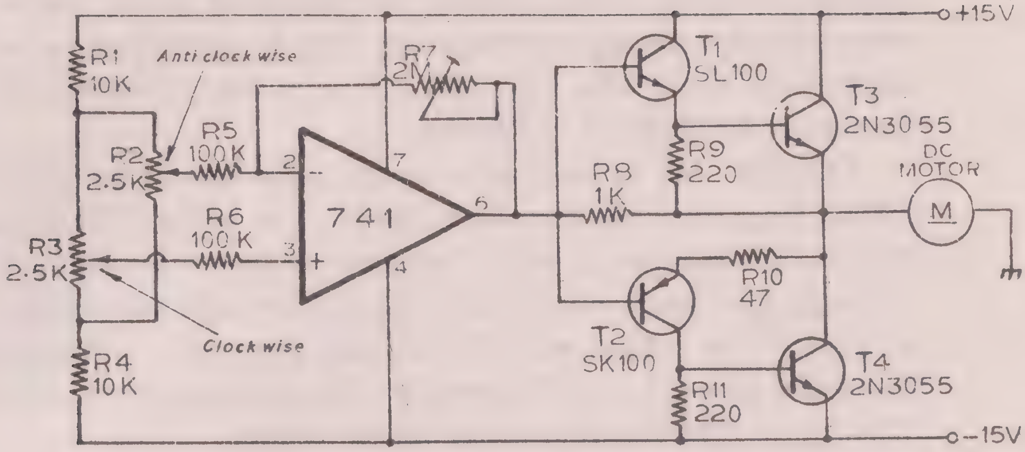


Fig. 21. DC Motor Control.

Fig. 21 shows a circuit for continuous remote control of speed and direction of rotation of a dc motor. Such a circuit is suitable for antenna rotators and similar applications.

Basically, the circuit is a dc amplifier (see Figs. 4 and 5) followed by a direct coupled power amplifier comprising of transistor pairs T1, T3 and T2, T4. Resistor R7 sets the system sensitivity and potentiometers R2 and R3 control the speed and direction of rotation.

19. AC MOTOR CONTROL

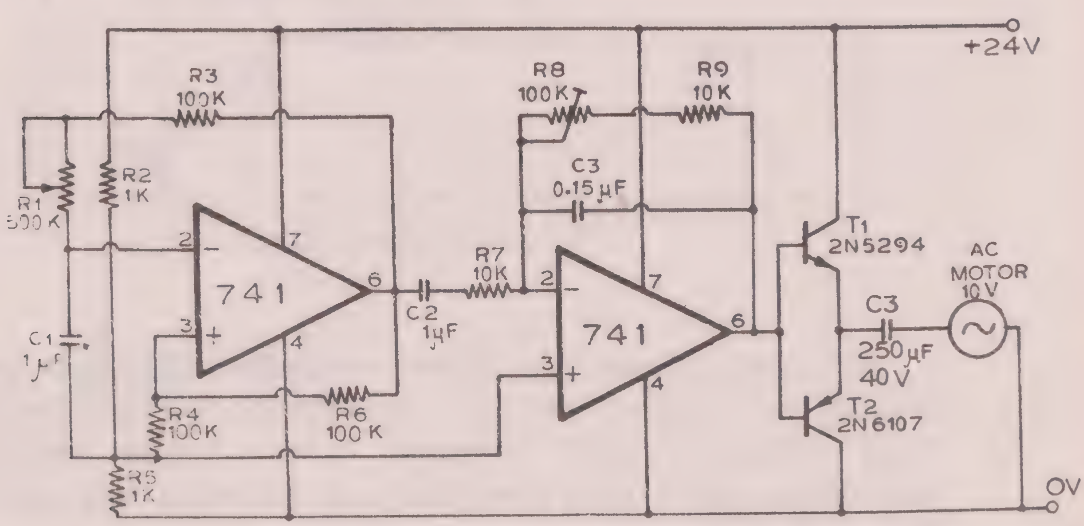


Fig. 22. Speed Control of AC Motor.

The speed of an ac motor depends on the frequency of supply voltage. Hence, within limits, the speed of an ac motor can be controlled by varying the frequency. Fig. 22 shows a circuit which can control the speed of a small 10 volt ac motor by varying the supply frequency from 30 Hz to 120 Hz.

The first 741 is used as a square wave generator (see Fig. 24) whose frequency can be varied by R1. The second 741 is used as an integrator. Because of heavy capacitive negative feedback, this stage converts the square waves into triangular waveforms which is almost as suitable as a sine wave for driving the motor. Complementary transistor pair T1 and T2 provides the required drive to the motor. The circuit operates on a single power supply.

20. SCHMITT TRIGGER

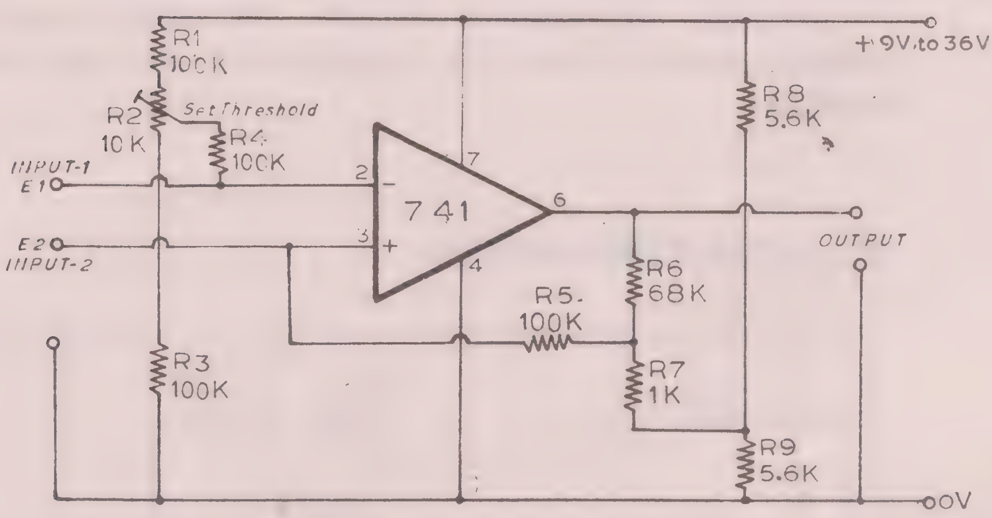
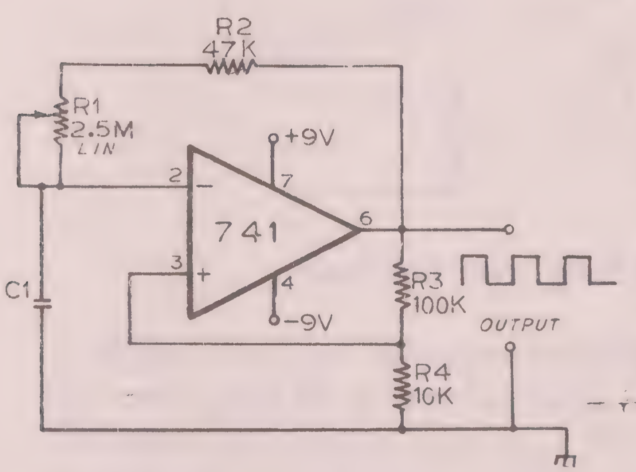


Fig. 23. A Schmitt Trigger.

A Schmitt trigger circuit shows two distinct signal input levels for turning the circuit 'on' and 'off'. The difference between the V_{on} and V_{off} voltages is called 'hysteresis'. Schmitt triggers are useful in converting slowly rising waveforms into fast rising ones and in relay like applications.

The circuit shown in Fig. 23 uses a 741 with positive feedback via R5, R6 and R7 for fast switching. Voltage dividers R8 and R9 set the dc input voltage to the non-inverting input terminal to half the supply voltage. The amount of positive feedback depends on the ratio of R6 and R7. The larger the ratio, the smaller will be the hysteresis shown by the circuit. Potentiometer R2 sets the dc voltage to the inverting input terminal and thus sets the threshold voltage at which the signal will trigger the circuit. The input signal can be applied to either of the two input terminals.

21. SQUARE WAVE GENERATOR



C1	FREQUENCY MIN	MAX
1 μF	1 Hz	25 Hz
0.1 μF	10 Hz	250 Hz
0.01 μF	100 Hz	2.5 KHz
0.001 μF	500 Hz	10 KHz

Fig. 24. Wide Range Square Wave Generator.

A wide range square wave generator using a 741 is shown in Fig. 24. The circuit uses positive feedback for Schmitt trigger action and negative feedback for timing of the waveform.

Let us presume that the output is high and the capacitor C1 is completely discharged. C1 now starts charging via R2 and R1. When the voltage across C1 rises above that at the junction of R3 and R4, the output quickly switches to fully negative voltage. C1 now starts discharging and charges in the opposite direction. Again, when the negative voltage across C1 falls below that at pin 3, the circuit switches back quickly to the fully positive output value. The cycle repeats endlessly. The table in the figure gives the relationship between the values of C1 and the frequency ranges covered. The fre-

quency range can be changed by altering the ratio of R3 and R4. Since the capacitor C1 charges and discharges through the same resistors, the output is a symmetrical square wave.

22. PULSE GENERATOR.

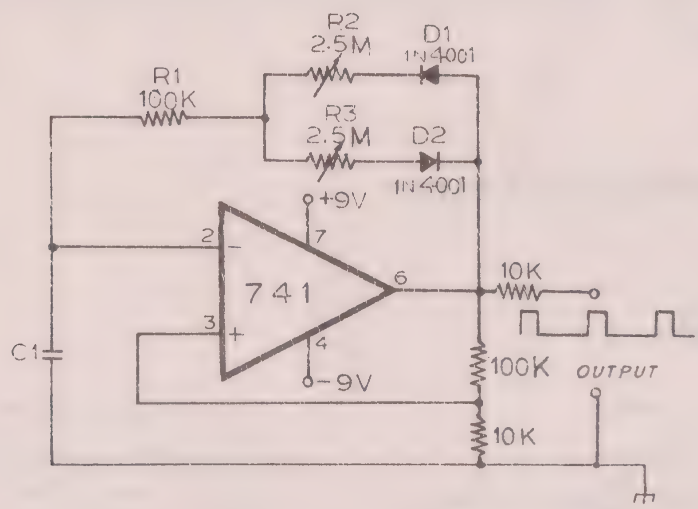


Fig. 25. A Wide Range Pulse Generator.

The wide range pulse generator shown in Fig. 25 is similar in operation to the square wave generator of Fig. 24 except that the charge and discharge paths of C1 have been separated by diodes D1 and D2. C1 therefore charges through D1, R2 and R1 and discharges through R1, R3 and D2. The period for which the output is 'high' or 'low' can now be controlled independently by R2 and R3. Thus the pulse width and the time interval between the pulses can be controlled to produce pulses of any duty ratio and repetition rate by choosing C1 correctly and adjusting R2 and R3 properly.

23. MULTITONE BELL

A multitone call bell saves up and down trips by distinguishing between calls made from the front door or back door or a side entrance. A three-tone circuit using a 741 is shown in Fig. 26.

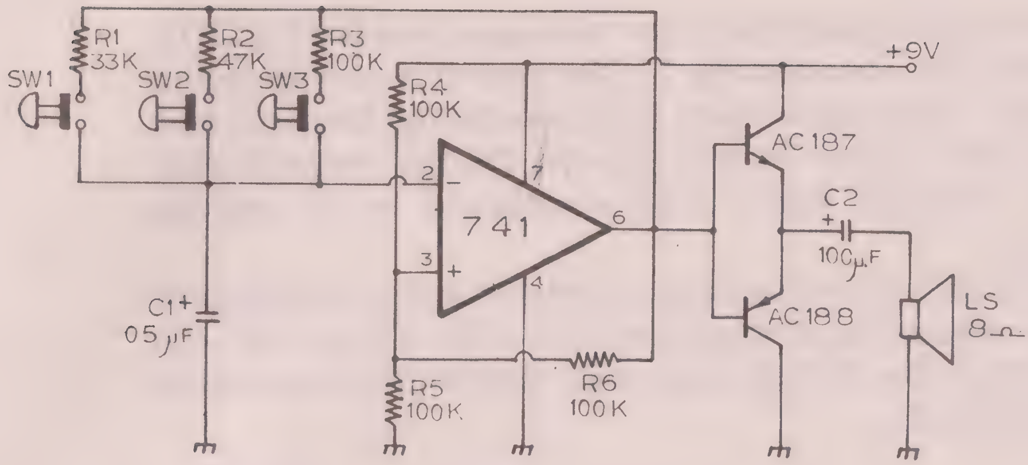


Fig. 26. Multitone Bell.

The circuit is basically a square wave generator (see Fig. 24) in which the three resistors R1, R2 and R3 produce different tones when any of the three call buttons is pressed. The output of 741 is amplified by a complementary transistor pair T1 and T2 to give a loud tone in the speaker.

24. ELECTRONIC SIREN

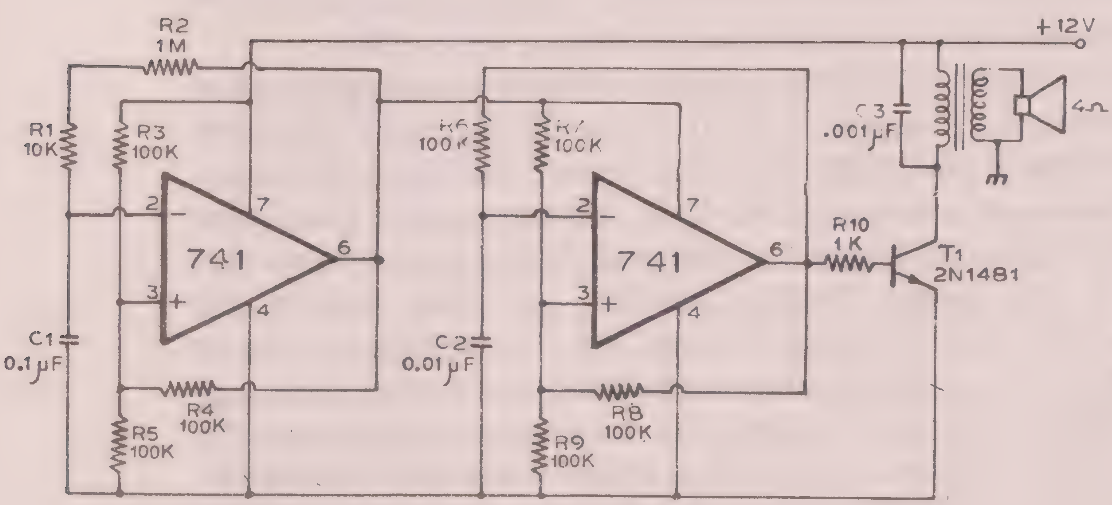
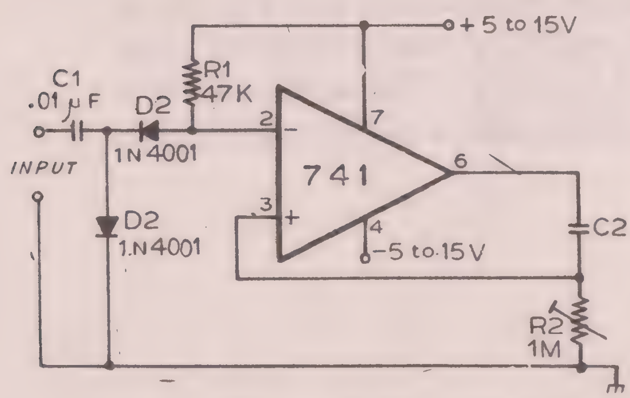


Fig. 27. Electronic Siren.

Another application of the square wave generator (see Fig. 24) is the electronic siren shown in Fig. 27. The first 741 is a low frequency multivibrator, the output of which modulates the high frequency tone produced by the second 741 multivibrator. The final output is amplified and converted into a loud siren sound by T1 and the loudspeaker.

Different and interesting tones can be obtained by changing the frequency determining components viz C1, R2, C2 and R6. For example if the value of C1 is made large, the siren will be turned on and off periodically.

25. MONOSTABLE MULTIVIBRATOR



R2 M Ω	C2 μF	t m. sec
0.5	10	500
0.5	1	50
0.5	0.1	5
0.5	.01	0.5

Fig. 28. A Monostable Multivibrator.

The output of a monostable multivibrator, when triggered once, remains high for a predetermined period and then falls back to its normal value. Such circuits are useful in timing applications.

A monostable multivibrator using a 741 and operating on a dual symmetrical power supply is shown in Fig. 28. Normally, R1 keeps the dc voltage at pin 2 higher than that on pin 3 and hence, the output at pin 6 stands at its fully negative value. A sharp negative going pulse at the input terminal lowers the voltage at pin 2 to a value below that at pin 3. The output therefore, quickly goes fully positive and capacitor C2 starts charging through R2. The voltage developed across R2 by the charging current maintains the output to its high value. When C2 has fully charged, the charging current drops and the circuit quickly returns to its normal position, ready to be triggered by the next input pulse. The periods for different values of C2 and R2 are shown in the table.

26. BISTABLE MULTIVIBRATOR

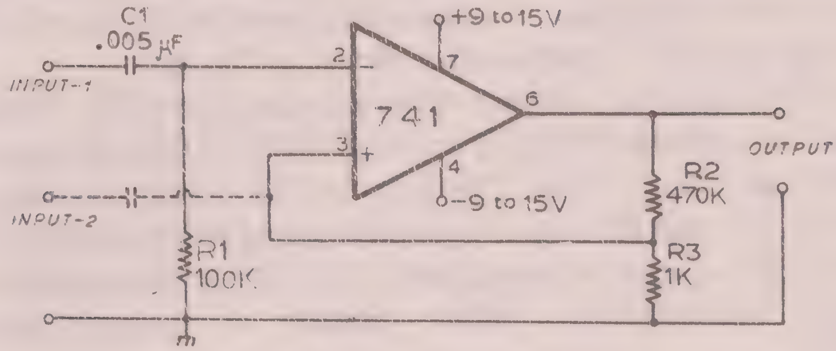


Fig. 29. A Bistable Multivibrator.

A bistable multivibrator using a 741 is shown in Fig. 29. The output in this case remains latched to its previous position, high (output fully positive) or low (output fully negative) till the state is changed by a trigger pulse.

The latching action is obtained by a small amount of positive feedback provided by R2 and R3. A negative trigger pulse at input-1 or a positive pulse at input-2 will change the output from low to high. Similarly, a positive pulse at input-1 or a negative pulse at input-2 will change the output state from high to low. The circuit output will remain latched in that position till the next pulse of the proper polarity is applied. Such circuits are useful in control applications.

27. TRIGGER PULSE GENERATOR

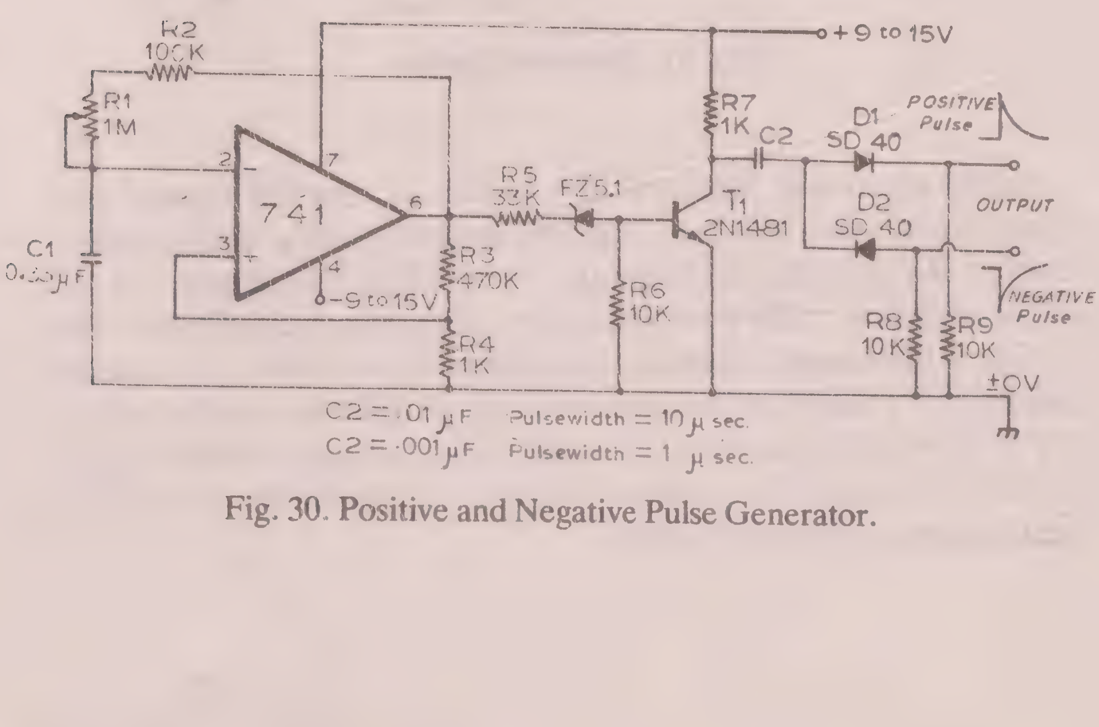


Fig. 30. Positive and Negative Pulse Generator.

The monostable and the bistable multivibrators require sharp pulses for their triggering. A circuit that provides sharp positive or negative going pulses repetitively is shown in Fig. 30.

The 741 is used as a square wave generator (see Fig. 24) whose frequency is controlled by R1. The output of 741 is directly coupled to T1 via R5 and a zener diode. The output at the collector is differentiated by C2, D1 and R9 to give a positive going pulse; and by C2, D2 and R8 to give a negative going pulse. The output pulses can be used to trigger multivibrators either directly or through coupling capacitors.

28. FLASHER

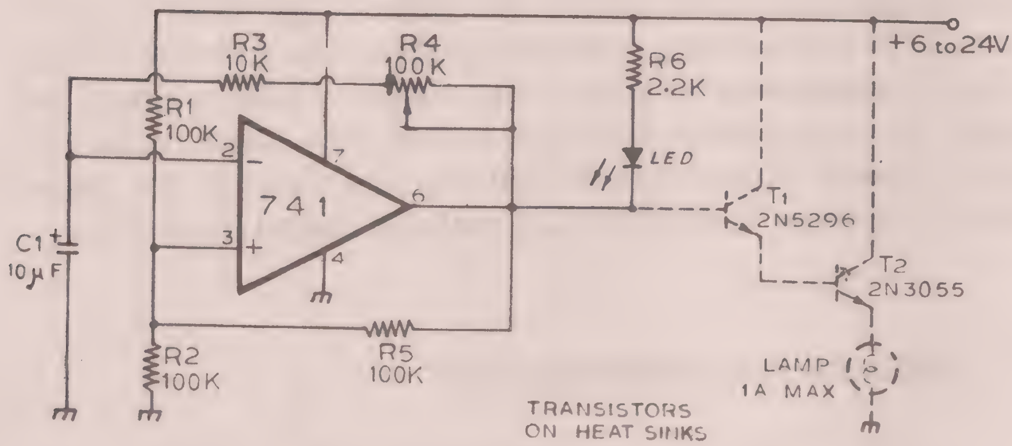


Fig. 31. Electronic Flasher.

In the electronic flasher shown in Fig. 31, the 741 is used as a square wave generator (see Fig. 24) operating on a single supply. Resistor R4 sets the flashing rate. If an LED is connected to the output as shown in the figure, the circuit becomes a tiny flasher. For making a high power flasher, omit R6 and the LED and connect transistors T1 and T2 in a compound emitter follower configuration. T2 provides sufficient drive to the lamp. For flashing 230 volts lamps, replace the lamp in the emitter circuit of T2 by a relay and a diode combination as shown in Fig. 32.

29. TIMER

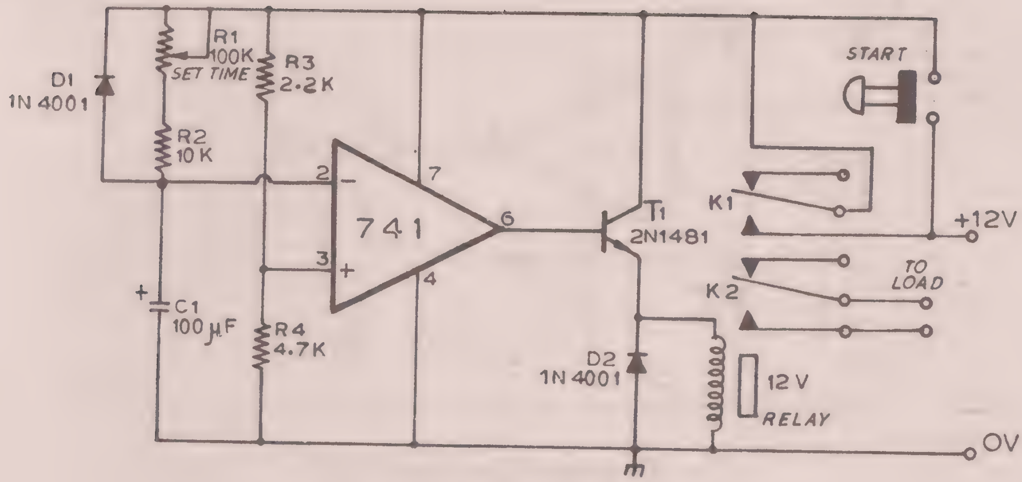


Fig. 32. Electronic Timer.

In the timer circuit of Fig. 32, the 741 is used as a voltage comparator. The supply to the 741 is applied either through the START switch or through the K1 contacts of a DPDT relay. A momentary touch on the START switch applies power to the 741. At this time, the input voltage at pin 2 is zero because C1 is completely discharged, and the voltage at pin 3 is about 2/3 of the supply voltage. The output of 741 is therefore fully positive and the relay latches. Capacitor C1 now charges slowly through R1 and R2. When the voltage across C1 exceeds that at pin 3, the output of 741 goes to almost zero and the relay is de-energised. This interrupts the supply line and C1 quickly discharges through D1 and T1. The circuit is now ready for next timing cycle. The stand-by power consumption of the circuit is zero and hence, the arrangement is suitable for battery operation.

30. LIGHT OPERATED RELAY

The light operated circuit shown in Fig. 33 will switch off a relay when the light falling on the LDR (Light Dependent Resistor) falls below a certain intensity. It can be used as an obstacle alarm.

When the light intensity is low, the LDR resistance is high and so is the voltage at pin 2. The output at pin 6 is therefore almost zero and the relay is open. When the light intensity increases above a certain value, the voltage at pin 2 falls below that at pin 3 and, because of

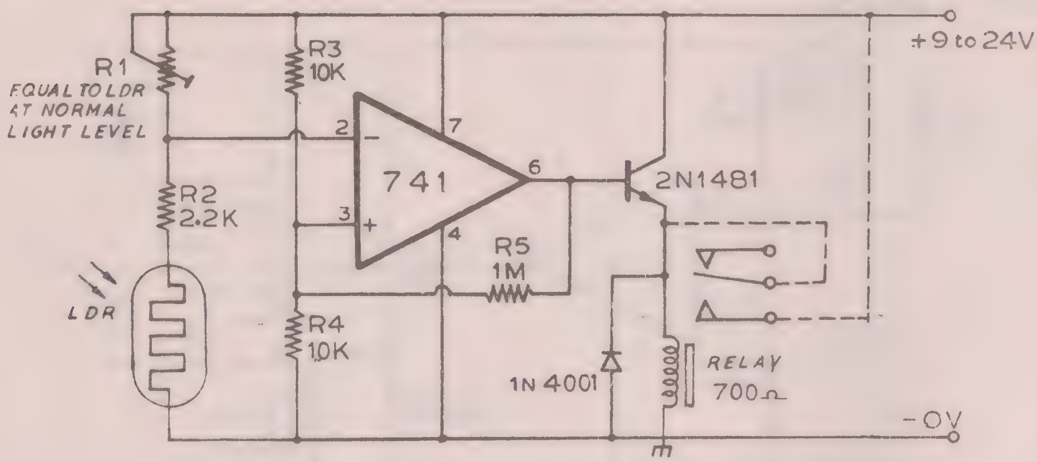


Fig. 33. Light Operated Relay.

positive feedback, the output quickly rises to fully positive value. This energises the relay. The positive feedback via R5 introduces a Schmitt trigger action (see Fig. 23) and the consequent hysteresis eliminates the relay chatter. The diode in parallel with the relay protects the transistor from high voltages induced in the relay coil during switch off. The dotted lines show the connections for a latching action, if required. In that case, the circuit can be de-energised by interrupting the supply line momentarily.

31. POWER FAILURE INDICATOR

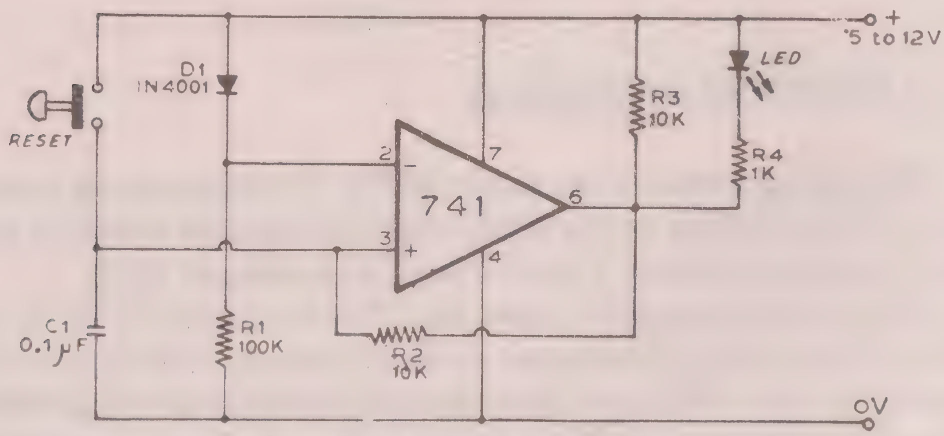


Fig. 34. Power Failure Indicator.

Many circuits, especially digital systems must have a continuous power supply to ensure correct operation. For example, a digital clock owner must know that the clock has to be reset to correct time. The circuit in Fig. 34 indicates power failure by a glowing LED.

When the supply is switched on, the voltage at pin 2 of 741 is 0.6 volts lower than the supply voltage. Pressing the reset button makes pin 3 voltage higher than that at pin 2 and the output swings high. Positive feedback via R2 makes the circuit latch in this state. The LED is therefore not lit.

When the supply is interrupted all voltages fall to zero. Upon restoration of the supply the inverting input is immediately pulled up to its previous voltage via Di. However, C1 being uncharged, holds the voltage at the non-inverting input low. The output of 741 therefore swings low thereby lighting the LED. The circuit stays in this state till the reset button is pressed again.

32. TOUCH CONTROLLER

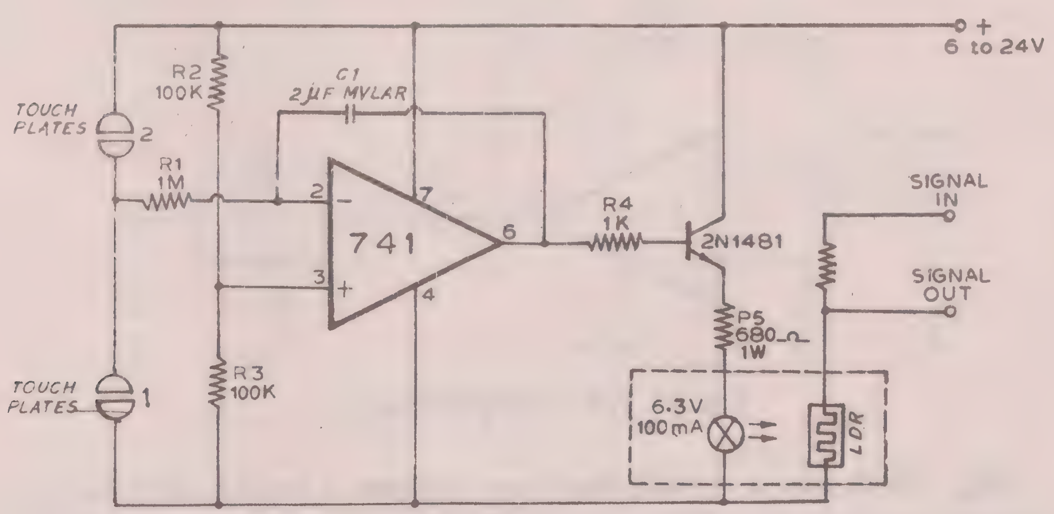


Fig. 35. Touch Controller.

The simple touch controller shown in Fig. 35 gives a dc output voltage which can be varied by touching two pairs of touch contacts. It may be used to drive a variety of voltage-controlled circuits such as voltage-controlled oscillators, voltage-controlled attenuators and amplifiers.

The 741 is used as an inverting integrator. The non-inverting input is held at half the supply voltage by R2 and R3. The output voltage therefore stands at half the supply voltage. If the lower pair of touch contacts is bridged by a finger, the voltage at pin 2 of the IC falls. The integrating action of the IC tries to keep this voltage equal to that at pin 3. Hence, the output voltage rises and the charging current through C1 and R1 tries to keep the voltages at pins 2 and 3 equal. A similar action in the opposite direction takes place when the upper pair of contacts is bridged by a finger. The net effect is that the output voltage can be controlled by the touch on the two pairs of contacts. An example to use the output voltage for making a voltage controlled attenuator using a lamp and an LDR is also shown in the figure. Due to input bias current of 741 the output voltage will tend to drift with time. For long term stability, replace 741 with a FET input op-amp like S356C.

33. FM TUNING INDICATOR

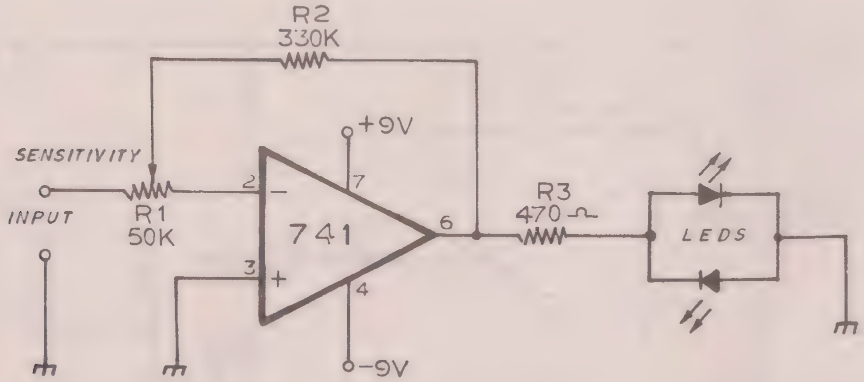


Fig. 36. FM Tuning Indicator.

Fig. 36 shows a circuit that can replace a centre-zero tuning indicator meter in an FM receiver. The input terminals can be connected directly in place of the meter. The indication sensitivity is set by R2. Correct tuning is indicated when both the LED's are off.

34. POSITIVE REFERENCE VOLTAGE

Fig. 37 shows a variable positive voltage reference\supply. The reference voltage can be set to precise values by R2.

36. REGULATED POWER SUPPLY

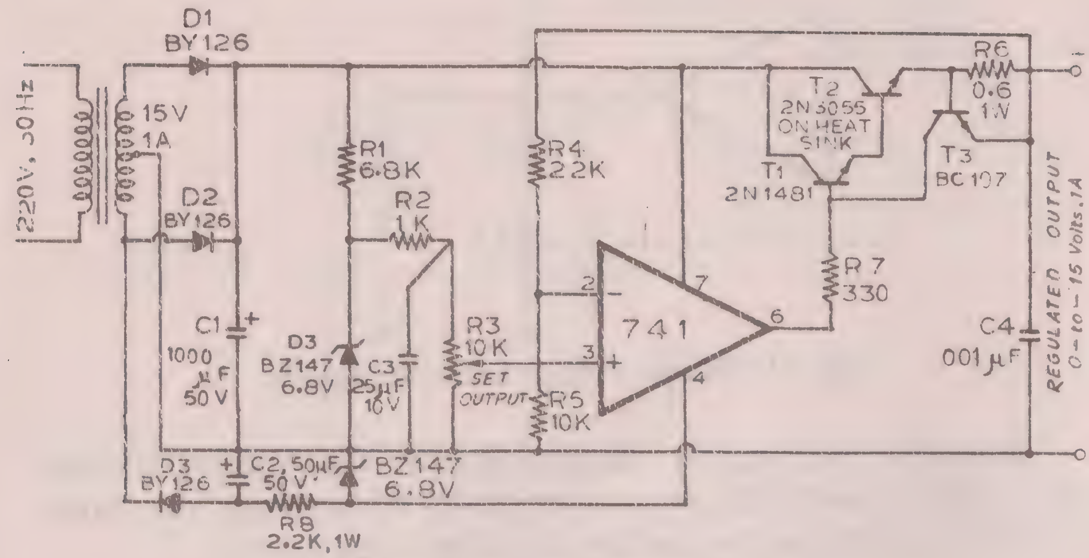


Fig. 39. Voltage Regulated DC Power Supply.

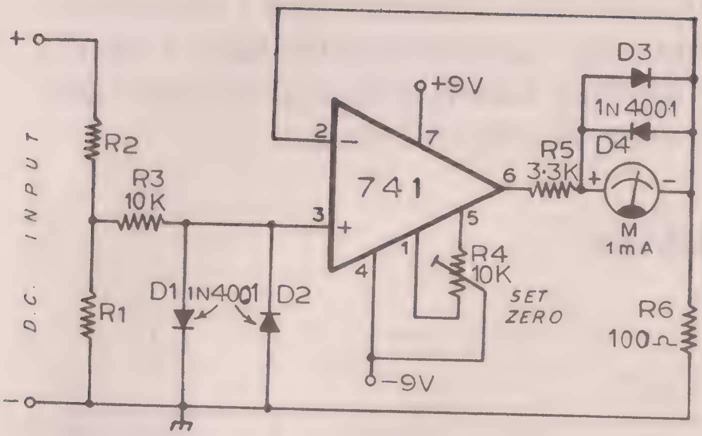
The voltage regulated power supply shown in Fig. 39 provides an adjustable voltage output at a load current up to 1A. The supply has a built-in overload protection.

Rectifier diodes D1 and D2 along with filter capacitor C1 provide the main unregulated supply. D3, C2, R8 and a zener diode provide a negative voltage supply for the 741. The non-inverting input terminal of 741 is given a stable voltage by R3 which is the control to set the output. A fraction of the regulated output is fed back via R4 and R5 to the inverting input terminal. The operational amplifier adjusts its output voltage so as to keep the voltage at the input terminals equal. Thus the output gets regulated. The output of 741 is amplified by a compound emitter follower T1 and T2.

All the load current flows through R6. If the load current exceeds 1A, the voltage drop across R6 exceeds 0.6 volts and T3 starts conducting. This bypasses the supply to T1 and T2 and the regulating action stops. The output voltage therefore starts falling when the load current exceeds 1A. Any of the output terminals can be grounded to get a positive or a negative voltage with respect to the ground.

37. DC VOLTMETER

A high impedance dc voltmeter using a 741 is shown in Fig. 40. The operational amplifier is used as a non-inverting dc amplifier (see



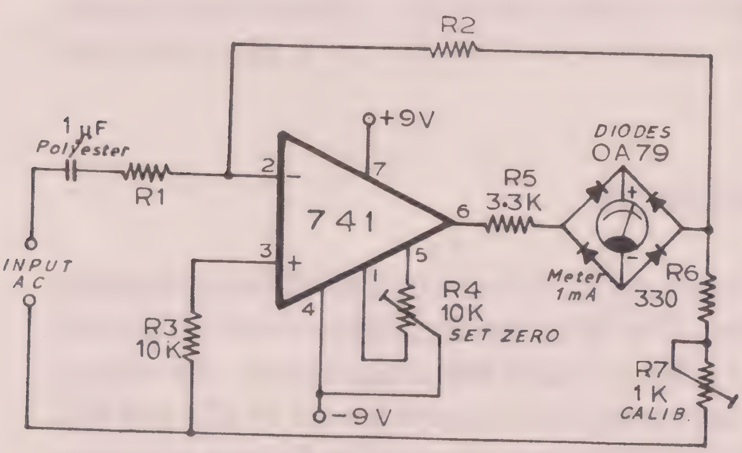
R1	R2	Full Scale Voltage
100K	900K	1V
100K	10M	10V
10 K	10M	100V

Fig. 40. High Impedance DC Voltmeter.

Fig. 5) in which the negative feedback is through a dc meter requiring 1mA for full scale deflection. Since R6 is 100 ohms, the meter will show full scale reading when the dc input voltage to pin 3 is equal to the voltage drop across R6, viz 0.1 volts. Choice of R1 and R2 for getting different voltage ranges are shown in the table.

Diodes D1 and D2 protect the IC from accidental excessive input voltages and diodes D3 and D4 protect the meter from overloads.

38. AC MILLIVOLTMETER



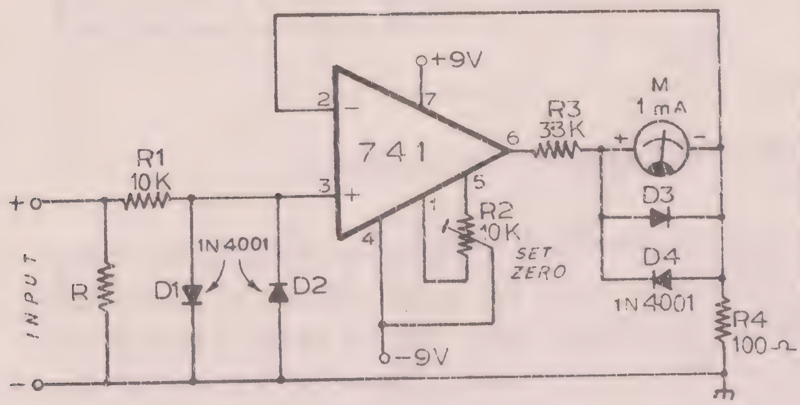
R1	R2	Full Scale Voltage
1K	1M	1 mV
10K	1M	10 mV
100K	1M	1V
1M	1M	10V

Fig. 41. AC Millivoltmeter.

The ac millivoltmeter shown in Fig. 41 uses a 741 as an inverting amplifier. The negative feedback is through a bridge rectifier and R2. The operational amplifier output overcomes the barrier voltage of

the diodes and gives linear rectification characteristics. Choice of R1 and R2 for getting different ranges are shown in the table. Calibration control R7 is set by applying known voltage at the input and adjusting R7 till the meter reads the correct voltage.

39. MICROAMPERE METER



R	Full Scale Current
100K	1 μA
10K	10 μA
1K	100 μA
100	1 mA

Fig. 42. Microammeter.

The microampere meter shown in Fig. 42 is basically a dc millivoltmeter similar to that shown in Fig. 40. The circuit gives full scale deflection for 0.1V input. The current to be measured is passed through a known resistance R and the voltage drop across it is measured. The table in the figure shows the relationship between different values of R and the current that will give full scale deflection.

40. ENGINE RPM COUNTER

The analog meter shown in Fig. 43 indicates the RPM of an engine by deflection on a meter. The input signal is taken from the contact points of the engine. As the contacts make and break, the voltage across the contacts is converted into square waves by D1 and D2. Capacitor C1 differentiates these square waves and sharp pulses are applied to the inverting input of 741. Zener diodes D3 and D4 provide a regulated supply to the IC as well as provide a mid point for giving half the supply voltage to the non-inverting input terminal. The 741, acting as a pulse stretcher, gives a pulse of fixed amplitude

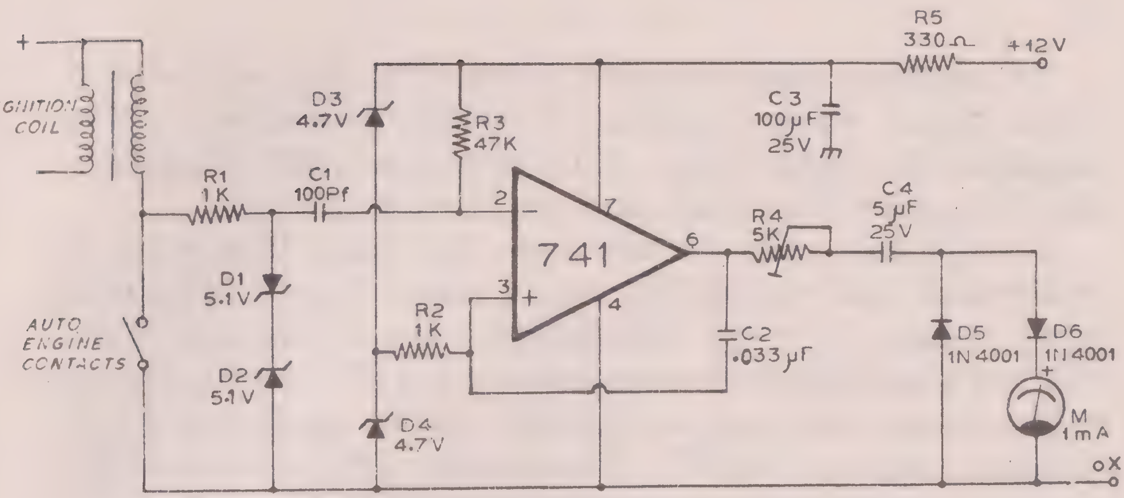


Fig. 43. RPM Counter.

and fixed duration for each input pulse. These pulses are rectified by D5 and D6 and the average current through the meter is directly proportional to the engine RPM. For some particular setting, the engine RPM are measured by a stroboscope and R6 is set till the meter reads the same RPM.

41. ANALOG TO DIGITAL CONVERTER

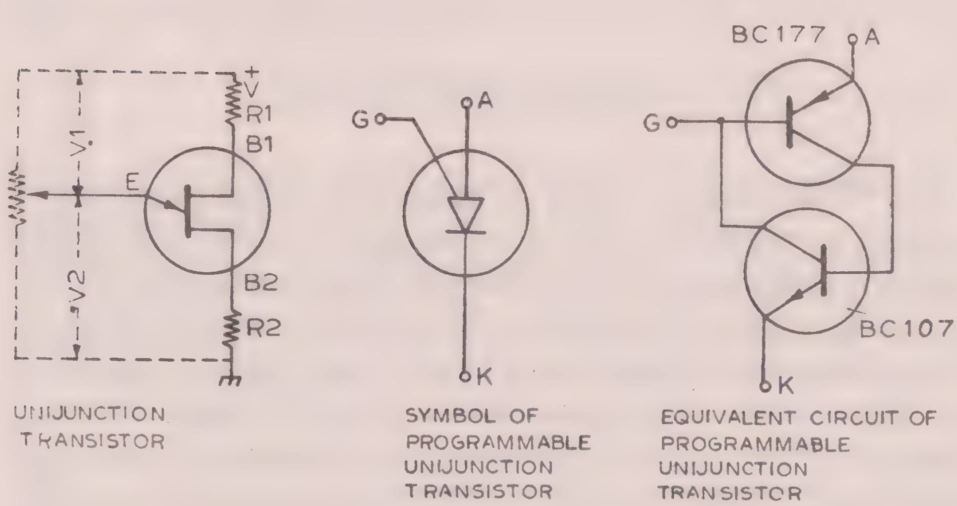


Fig. 44. UJT, Symbol for Put and Put Equivalent.

The analog-to-digital converter shown in Fig. 45 gives a saw tooth output signal whose frequency is directly proportional to the magnitude of dc input voltage. As the circuit uses a PUT (Programmable Unijunction Transistor), let us see how a PUT works.

A unijunction transistor fires when the voltage V_2 between its emitter and base two (see Fig. 44) is a certain fraction of the total supply voltage (V_1+V_2). This fraction is the characteristic of the UJT and is specified by the manufacturer. In a PUT this fraction can be altered and can be set to a desired value by application of a dc voltage to the gate of the PUT. The symbol for a PUT is shown in Fig. 44. Two complementary transistors can also be connected in a regenerative manner to give PUT like operation characteristics.

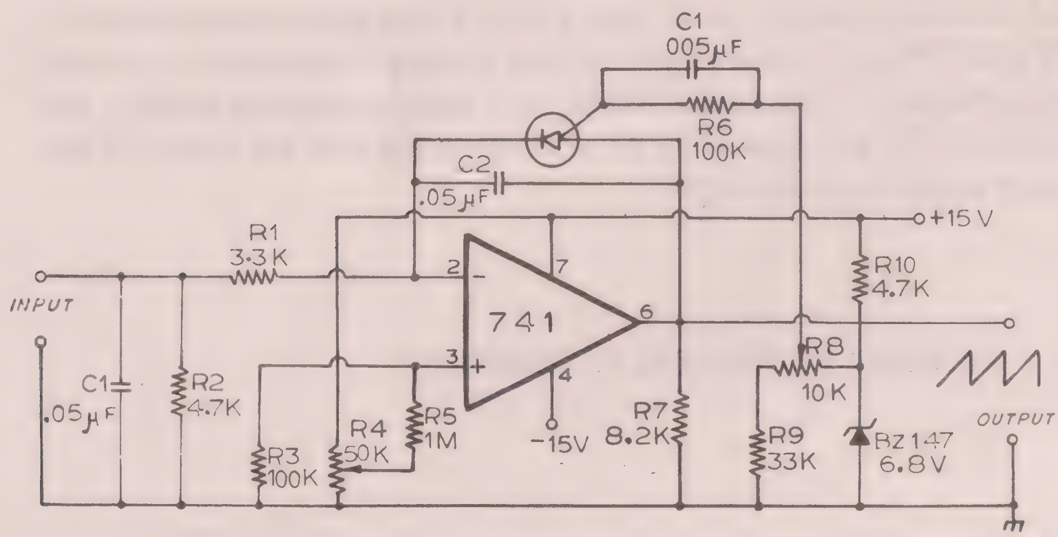


Fig. 45. Analog to Digital Converter.

In Fig. 45 the 741 is used as an integrator. When a negative dc input signal is applied to the inverting input via R1, the output voltage starts rising linearly and capacitor C2 starts charging. As soon as the voltage across the capacitor C2 reaches a certain value, the PUT fires, the output voltage at pin 6 falls to zero and the cycle starts again. The capacitor charging current is given by $V_{in}/R1$, therefore the frequency of the output signal is directly proportional to the input signal voltage. Potentiometer R8 is set to give a convenient multiplier say 100 or 1000 so that a digital counter directly indicates the input voltage. R4 is used to set the input signal threshold to reject noise etc.

P35

3

POWER SUPPLIES

In most of the applications, the operational amplifiers require a dual supply. The current drawn by a 741 under no load conditions is about 3 mA only and the simplest power supply for its operation is a pack of two batteries connected as shown in Fig. 1. For mains operation different circuit configurations are given below:

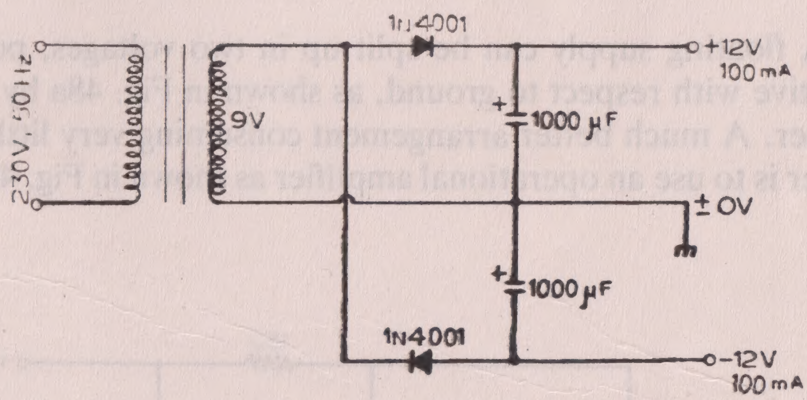


Fig. 46. Half Wave Rectifier.

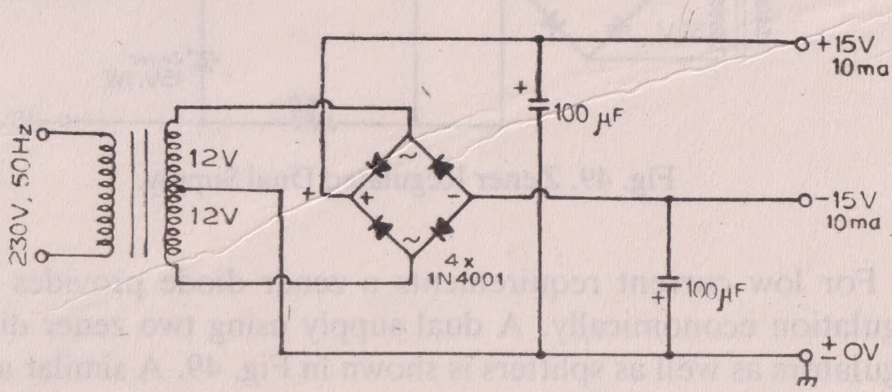


Fig. 47. Full Wave Rectifier.

A simple half-wave rectifier giving a dual output is shown in Fig. 46. A full-wave rectifier using a bridge connected as shown in Fig. 47 gives lesser hum and better load and supply regulation.

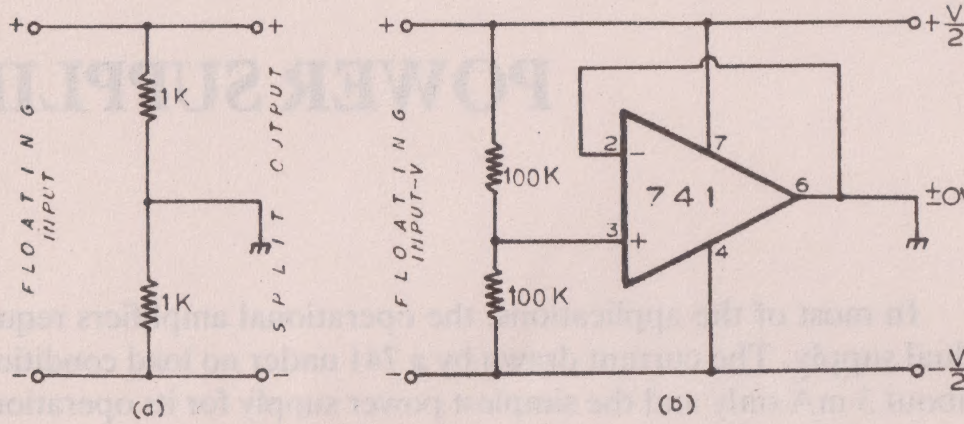


Fig. 48. Voltage Splitters.

A floating supply can be split up in two voltages, positive and negative with respect to ground, as shown in Fig. 48a by a resistive divider. A much better arrangement consuming very little stand-by power is to use an operational amplifier as shown in Fig. 48b.

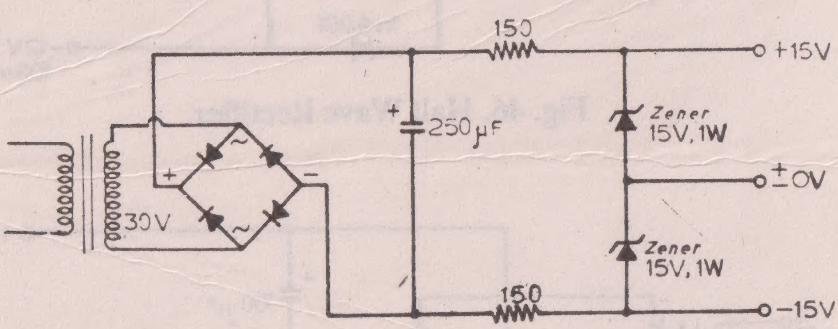


Fig. 49. Zener Regulated Dual Supply.

For low current requirements a zener diode provides enough regulation economically. A dual supply using two zener diodes as regulators as well as splitters is shown in Fig. 49. A similar arrangement can be used to give a dual low current supply from a high voltage dc supply as shown in Fig. 50.

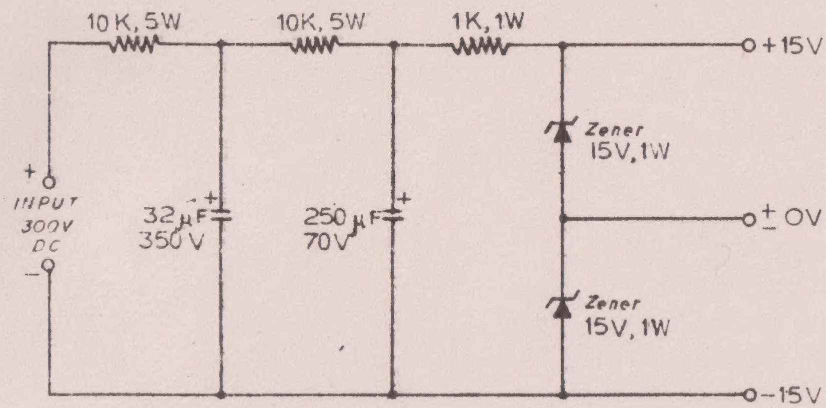


Fig. 50. Op Amp. Supply from a High Voltage DC Source.

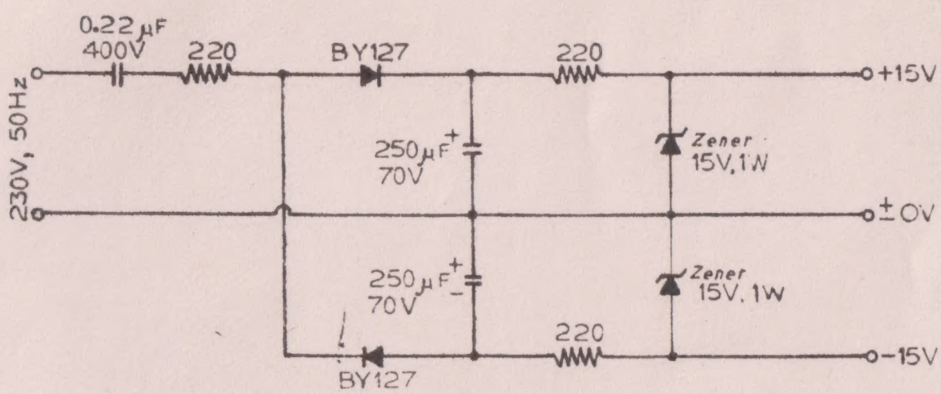


Fig. 51. Op Amp. Supply from High Voltage AC Source.

Fig 51 shows a transformerless dual low voltage power supply for operational amplifiers. A series capacitor is used as a voltage dropping device in place of a resistor. Such arrangements are good only for low current requirements.

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